

## **1.0 INTRODUCTION**

### **1.1 PURPOSE OF THE MONITORING PROGRAM**

The U.S. Army Corps of Engineers (USACE) manages F.E. Walter Reservoir located in northeastern Pennsylvania within the Delaware River Basin. Foremost, F.E. Walter Reservoir provides flood control and a dependable water supply to downstream communities on the Lehigh River. Additionally, the reservoir provides important habitat for fish, waterfowl, and other wildlife, and recreational opportunities through fishing, and boating. Due to the broad range of uses and demands F.E. Walter Reservoir serves, the USACE monitors water quality and other aspects related to reservoir health primarily to ensure public health safety. Water quality monitoring results are compared to state water quality standards and used to diagnose other problems that commonly effect reservoir health such as nutrient enrichment and toxic loadings. This report summarizes the results of water quality monitoring at F.E. Walter Reservoir from May through September 2003. This report also discusses the relevance of the water quality measures to the ecology of the reservoir and makes recommendations toward future water quality monitoring.

### **1.2 DESCRIPTION OF F.E. WALTER RESERVOIR**

F.E. Walter Reservoir is an integral part of the Lehigh River Flood Control Program. The authorized purpose of this project is flood control. The reservoir project was authorized as a white water project as part of Public Law 100-676, Section 6, dated November 17, 1988. Located about 9 miles southeast of Wilkes-Barre, PA, the reservoir dams a drainage area of 288 square miles. The dam can impound up to 35.8 billion gallons of floodwater. The primary surface water input into the reservoir is the Lehigh River as it flows west between Luzerne and Carbon Counties. Bear Creek, a secondary surface water input, enters the reservoir from the north. Tobyhanna Creek drains an area to the southeast and joins the Lehigh River near the headwaters of the reservoir. The reservoir is approximately 3 miles long and usually about 50 feet deep behind the dam. The 44 year average annual discharge from the dam into the Lehigh River is approximately 620 cubic feet per second (USGS 2004).

### **1.3 ELEMENTS OF THE STUDY**

The USACE, Philadelphia District, has been monitoring the water quality of F.E. Walter Reservoir since 1975. Over this time, yearly monitoring program designs have evolved to address new areas of concern such as health aspects of public drinking water, sediment contaminants within the reservoir basin, and most recently, investigating a hydrogen sulfide smell near the tail water of the dam. However, presence of hydrogen

sulfide was not investigated in 2003. The 2003 monitoring program is similar to those in recent years and includes the following major elements:

- Monthly water quality and bacteria monitoring from May through September to evaluate compliance with the Pennsylvania state water quality standards;
- Meteorological monitoring of air temperature, relative humidity, solar radiation, wind speed and direction every ½ hour at the F. E. Walter Reservoir discharge tower;
- Sediment priority pollutant monitoring of acid/base neutral extractables and metals to evaluate sediment toxicity relative to identified screening concentrations;
- Drinking water monitoring to ensure public health safety by comparing water quality from a drinking water source to standards determined by the Safe Drinking Water Act (SDWA); and
- Automated half-hour temperature recorders at five stations along the Lehigh River below the reservoir from May to September

## **2.0 METHODS**

### **2.1 PHYSICAL STRATIFICATION MONITORING**

Physical stratification monitoring of the water column of F.E. Walter Reservoir was conducted five times between May and September 2003 (Table 2-1). Physical stratification parameters included temperature, dissolved oxygen (DO), pH, and conductivity. Monitoring was conducted at seven fixed stations located throughout the reservoir watershed (Fig. 2-1). Surface water quality was monitored at stations downstream of the reservoir (WA-1), and upstream on Tobyhanna Creek (WA-3), the Lehigh River (WA-4), and Bear Creek (WA-5). Stratification monitoring was conducted at the reservoir-body station (WA-2), Bear Creek (WA-6), and Lehigh River (WA-7) with water quality measured at the surface to the bottom at 5-ft intervals. All of the water quality monitoring was conducted with a calibrated Hydrolab water quality meter.

In this report, water quality data recorded from stratification monitoring were compared to water quality standards mandated by the Pennsylvania Department of Environmental Protection (PADEP Chapter 93). The standard for DO is a minimum concentration of 5 mg/L, and that for pH is an acceptable range from 6 to 9.

All of the water quality data collected during physical stratification monitoring are summarized in Appendix Table A-1.

### **2.2 WATER COLUMN CHEMISTRY MONITORING**

Water column chemistry monitoring was conducted five times at F.E. Walter Reservoir between May and September 2003 (Table 2-1). Water samples were collected at the seven fixed stations throughout the reservoir drainage area (Fig. 2-1). Surface water samples were collected at stations downstream of the reservoir (WA-1) and upstream on Tobyhanna Creek (WA-3), the Lehigh River (WA-4), and Bear Creek (WA-5). Surface, middle, and bottom water samples were collected at the reservoir-body station WA-2, WA-6, and WA-7. Surface water samples were collected by opening the sample containers approximately 1 foot below the water's surface. Middle and bottom samples were collected with a Van Dorn design water bottle.

Water samples collected from surface, middle, and bottom depths were analyzed for ammonia, nitrite, nitrate, total Kjeldahl nitrogen (TKN), total phosphorus, ortho-phosphate, soluble phosphorus, total dissolved solids (TDS), total suspended solids (TSS), biochemical oxygen demand (BOD), alkalinity, total organic carbon (TOC), total inorganic carbon (TIC), total carbon, and chlorophyll *a*. Table 2-2 summarizes the water quality parameters;

Table 2-1. F.E. Walter Reservoir water quality schedule for 2003 monitoring

Date of Sample Collection	Physical Stratification Monitoring (All Stations)**	Water Column Chemistry Monitoring (All Stations)	Trophic State Determination (WA-2)	Coliform Bacteria Monitoring (All Stations)	Sediment Priority Pollutant Monitoring (WA-2)	Lehigh Temperature Probes	Drinking Water Monitoring*
15 May	X	X	X	X		X	
10 June	X	X	X	X		X	Set A and B
16 July	X	X	X	X	X	X	
13 August	X	X	X	X		X	
24 September	X	X	X	X		X	Set A

Set B – comprised analyses for primary and secondary contaminants.  
\* Set A – comprised analyses of nitrate, nitrite, and coliform bacteria contaminants.

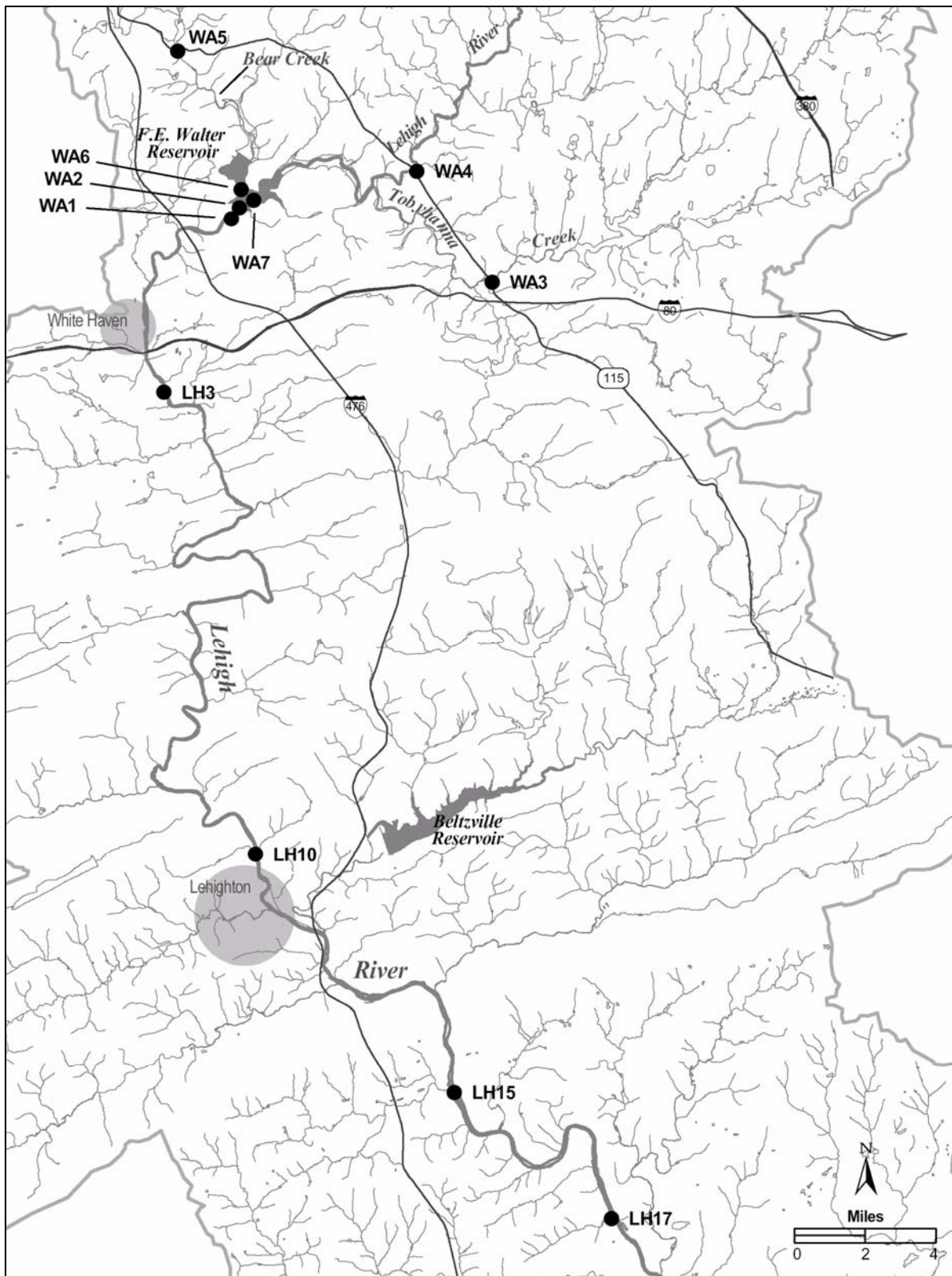


Figure 2-1. Location map for F.E. Walter Reservoir and water quality monitoring stations in 2003

laboratory method detection limits, state water quality standards, and allowable and achieved maximum hold times for each.

Table 2-2. Water quality test methods, detection limits, state regulatory criteria, and sample holding times for water quality parameters monitored at F.E. Walter Reservoir in 2003					
Parameter	EPA Method	Detection Limit	PADEP Surface Water Quality Criteria	Allowable Hold Times (Days)	Maximum Hold Time Achieved (Days)
Alkalinity	310.1	0.41 mg/L	minimum 20 mg/L CaCO <sub>3</sub>	14	8
Biochemical Oxygen Demand (BOD)	405.1	0.8 mg/L	None	2	1
Total Phosphorus	365.1	0.04 mg/L	None	28	9
Ortho-Phosphate	365.3	0.01mg/L	None	28	1
Soluble Phosphorus	365.1	0.05 mg/L	None	28	13
Total Organic Carbon	415.1	0.5 mg/L	None	14	8
Total Inorganic Carbon	415.1	0.6 mg/L	None	14	15
Total Carbon	415.1	0.6 mg/L	None	14	12
* Chlorophyll <i>a</i>			None		3
Total Kjeldahl Nitrogen	351.2	0.30 mg/L	None	28	14
Ammonia	350.3	0.03 mg/L	Temperature and pH dependent	28	15
Nitrate	353.2	0.04 mg/L	Maximum 10 mg/L (nitrate + nitrite)	28	13
Nitrite	353.2	0.015 mg/L		28	1
Total Dissolved Solids	160.1	9.7 mg/L	Maximum 500 mg/L	7	6
Total Suspended Solids	160.2	3 mg/L	None	7	6
* Chlorophyll <i>a</i> samples were calculated by averaging 10 readings per minute using a YSI 6600 with a chlorophyll sensor.					

## 2.3 TROPHIC STATE DETERMINATION

The trophic state of F.E. Walter Reservoir was determined by methods outlined by Carlson (1977). In general, this method calculates trophic state indices (TSIs) independently for total phosphorus and chlorophyll *a* concentrations, and secchi disk depth. Surface water measures of total phosphorus and chlorophyll *a* from chemistry monitoring were averaged in determining monthly TSI values. Secchi disk depth was measured only in surface waters at the reservoir-body station (WA-2). Trophic state determinations were made using criteria defined by Carlson (1977) and EPA (1983).

## 2.4 RESERVOIR BACTERIA MONITORING

Monitoring for coliform bacteria contaminants was conducted five times between May and September at F.E. Walter Reservoir. Surface water samples were collected in the same manner as for chemical parameter samples, and analyzed for total and fecal coliform bacteria contamination. Table 2-3 presents the test methods, detection limits, PADEP standards, and sample holding times for the bacteria parameters monitored at F.E. Walter Reservoir in 2003. The bacteria analytical method was based on a membrane filtration technique. All of the samples were analyzed within their maximum allowable hold times. At the end of the monitoring period, streamflow data (CFS) collected from USGS gauging stations in the region (Blakeslee and Stoddartsville) and precipitation data collected at the dam were used to correlate rainfall patterns with measured bacteria levels (see Section 2.5).

Table 2-3. Water quality test methods, detection limits, PADEP water quality standards, and sample holding times for bacteria parameters monitored at F.E. Walter Reservoir in 2003		
Parameter	Total coliform	Fecal coliform
Test method	SM 9222B	SM9222D
Detection limit	10 clns/100-mls	10 clns/100-ml
PADEP standard	-	Geometric mean less than 200 clns/100-ml (application of this standard is conservative because swimming is not permitted in the reservoir)
Maximum allowable holding time	30 hours	30 hours
Achieved holding time	< 30 hours	< 30 hours

Monthly coliform bacteria counts were compared to the PADEP water quality standard for bacteria. The standard is defined as a maximum geometric mean of 200

colonies/100-ml based on five samples collected on different days. Given our logistical limitations (all monthly sampling conducted on one day), we calculated the geometric mean based on all of the surface samples collected for each month. Although our sampling design does not fully meet PADEP guidelines, we feel that this interpretation of the coliform data meets the intent of the PADEP water quality standard for evaluating F.E. Walter Reservoir bacteria levels. Additionally, application of this standard is conservative because swimming and other human/water contact recreation is prohibited in the reservoir.

## **2.5 STREAMFLOW AND PRECIPITATION DATA**

Streamflow and precipitation data for the principal monitoring months from May to September were compiled from USACE records (Figs. 2-2 through 2-6). Streamflow data were collected from the USGS stations located in Blakeslee and Stoddartsville and reflect rainfall patterns throughout the F.E. Walter Reservoir watershed. Precipitation data was collected by F.E. Walter Reservoir personnel and reflects a more local condition of rainfall pattern.

Monthly monitoring on 15 May was conducted at a streamflow of 297-cfs (Fig. 2-2). In the beginning of June, streamflow began to increase because of a storm event on 31 May with precipitation of 3.09 inches. Monthly monitoring in June was conducted at a streamflow of 855-cfs (Fig. 2-3). Towards the end of June another rain event took place causing the streamflow to rise to 6135-cfs. The streamflow decreased during July averaging 358-cfs (Fig. 2-4). Monthly monitoring on 13 August was done at a streamflow of 834-cfs, which was after two rain events totaling 5.13 inches of rain (Fig. 2-5). September 24 monitoring was conducted the day after 2.08 inches of precipitation with flows of 4274-cfs (Fig. 2-6).

## **2.6 SEDIMENT PRIORITY POLLUTANT MONITORING**

Sediment from F.E. Walter Reservoir was monitored for priority pollutant contaminants, Group 2 – metals and acid/base neutral extractables. Sediment was collected on 16 July at station WA-2 with a petite ponar grab-sampler. Sediment from the grab-sampler was emptied into a stainless steel mixing bowl and homogenized with a stainless steel spoon. Sediments were contained in appropriately labeled sample jars and stored on ice until shipment to the analytical laboratory. All field equipment used during the handling of reservoir sediments was decontaminated prior to sampling. Decontamination procedures were as follows: detergent wash, first deionized water rinse, 10% nitric acid rinse, second deionized water rinse, hexane rinse, and third deionized water rinse. Table 2-4 summarizes the parameters monitored, method detection limits, sample hold times, and the laboratory methods used in the analyses.



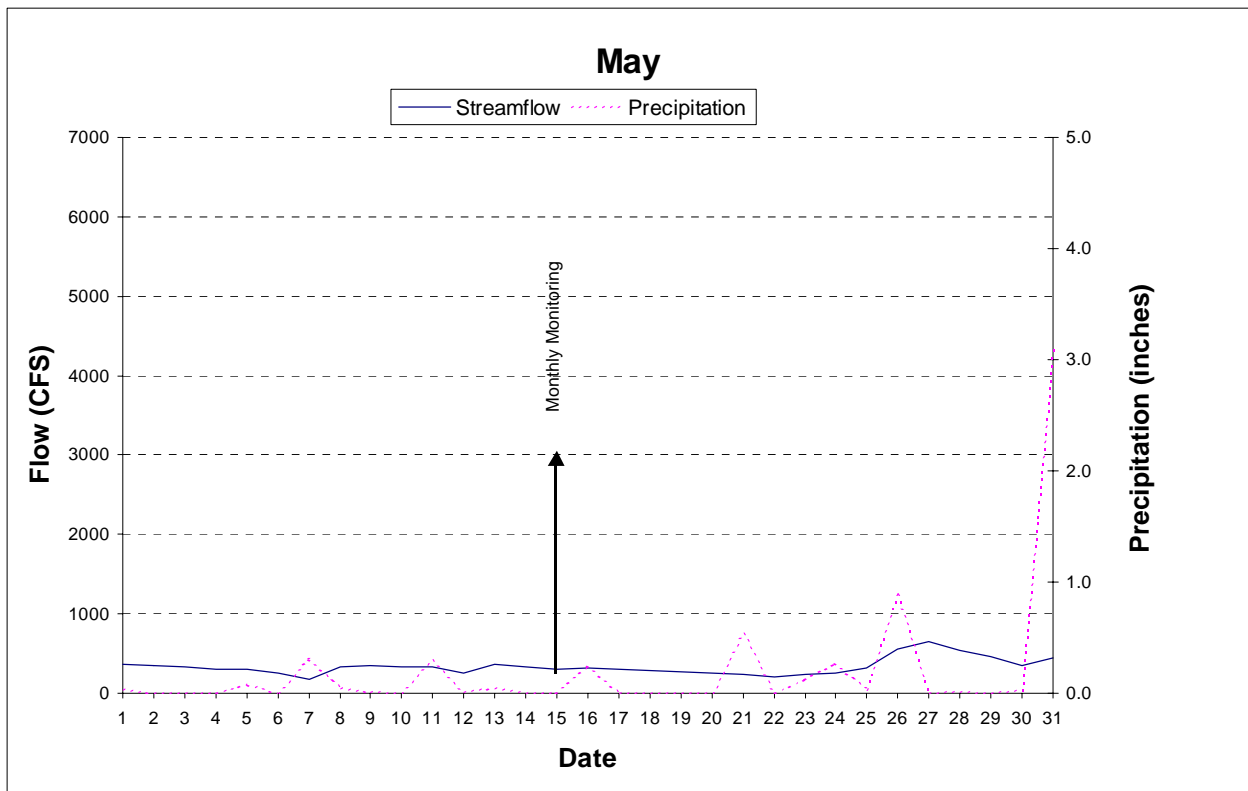


Figure 2-2. May streamflow and precipitation in the vicinity of F.E. Walter Reservoir during 2003

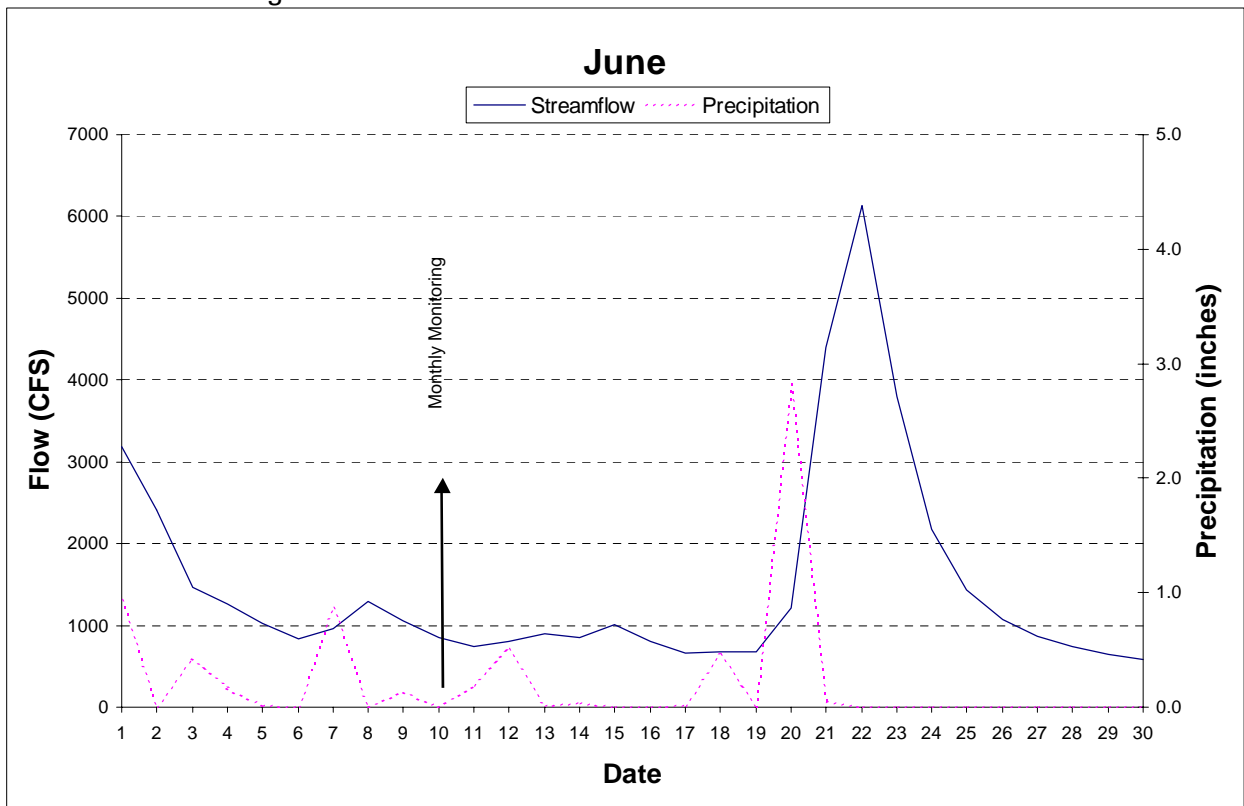


Figure 2-3. June streamflow and precipitation in the vicinity of F.E. Walter Reservoir during 2003

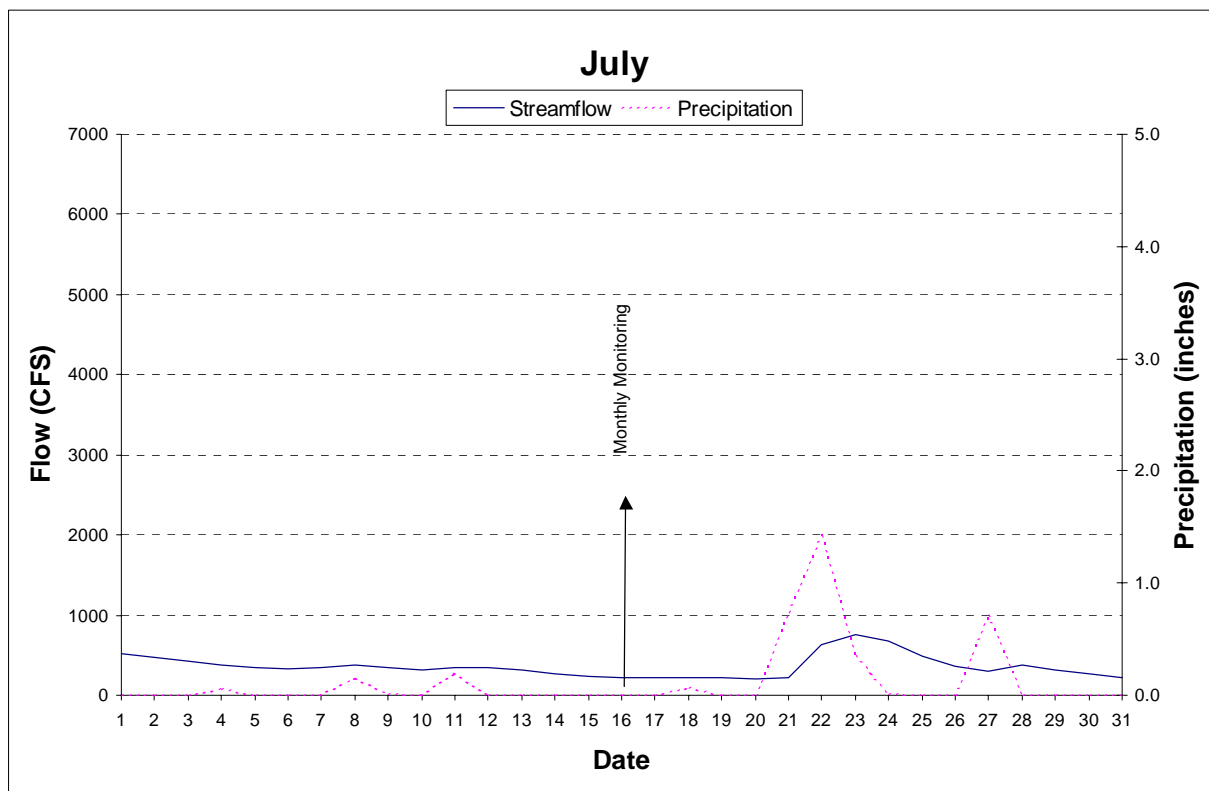


Figure 2-4. July streamflow and precipitation in the vicinity of F.E. Walter Reservoir during 2003

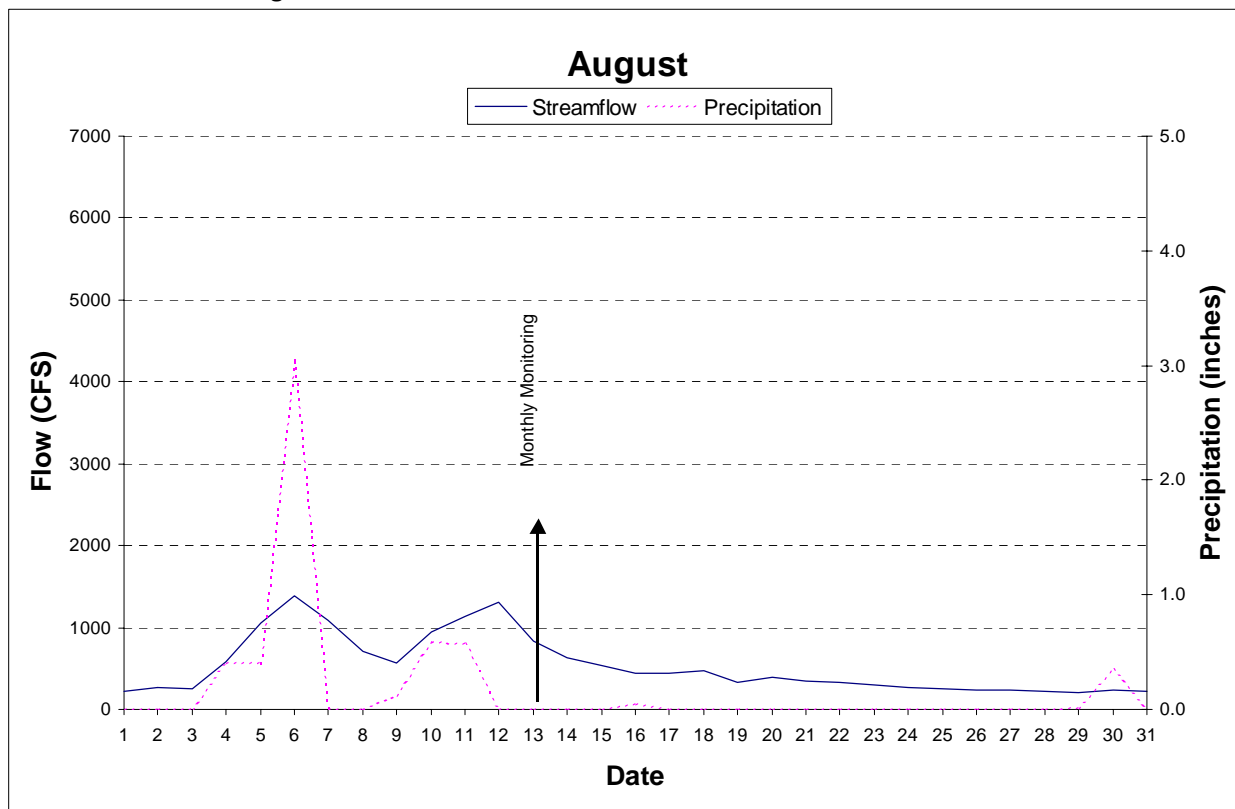


Figure 2-5. August streamflow and precipitation in the vicinity of F.E. Walter Reservoir during 2003

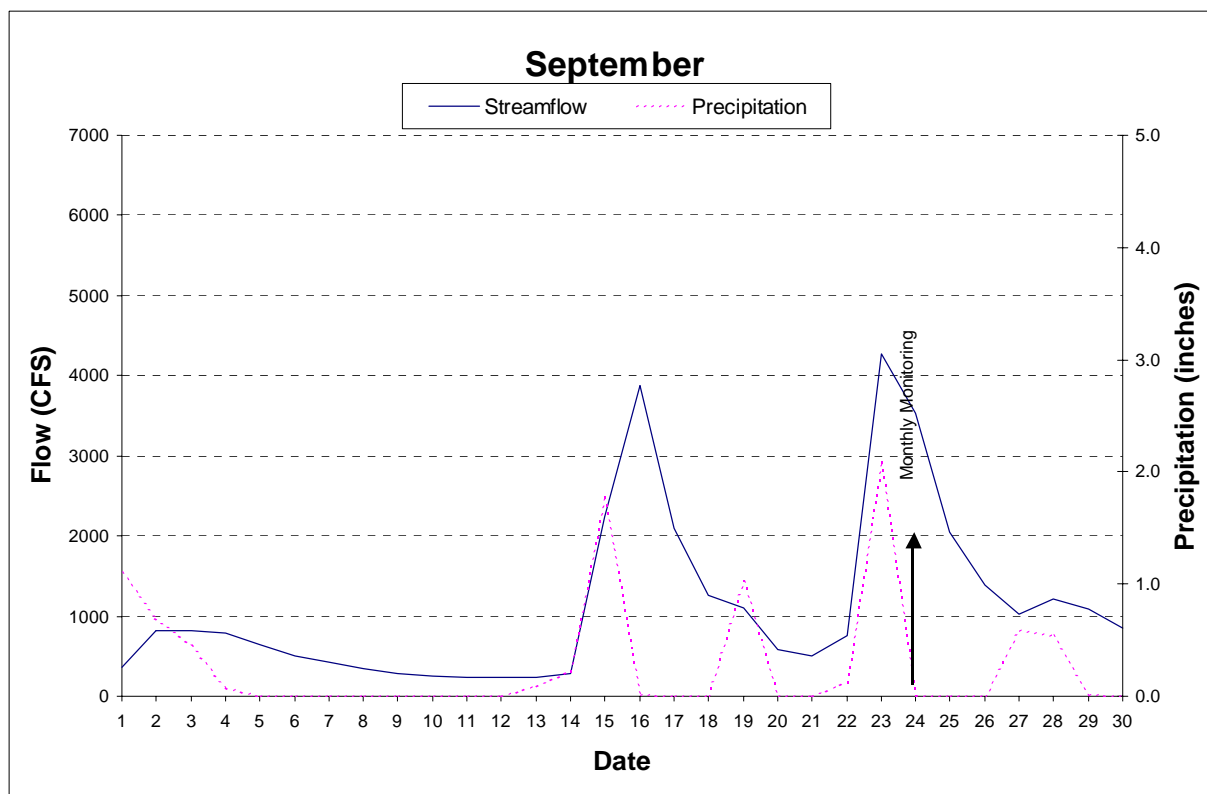


Figure 2-6. September streamflow and precipitation in the vicinity of F.E. Walter Reservoir during 2003

All sediment contaminant concentrations were reported on a dry weight basis, and were calculated as follows:

$$\text{Dry weight concentration (mg/kg)} = \frac{\text{Wet weight concentration (mg/kg)} \times 100}{\% \text{ solid of sample}}$$

Sample-specific detection limits were calculated for the sediment tests because of matrix interference and the conversion from wet weight to dry weight.

## 2.7 TREND ANALYSIS METHODS

Annual water quality, sediment contaminant, and drinking water monitoring have been conducted at F.E. Walter Reservoir since 1975. Data collected over these years were compiled in to an electronic database by the USACE (Versar 1996). The compilation of historical data enables the use of statistical trend analysis, an important tool in determining if the water quality at F.E. Walter Reservoir has significantly changed. A number of different trend analysis methods are available; some more complicated than others. For the purpose of this report, we employed two general methods: regression analysis and the Mann-Kendall, or Seasonal Kendall, test.

Table 2-4. Analytical methods, detection limits, and sample hold times for sediment priority pollutant metals and acid/base neutral extractables monitored at F. E. Walter Reservoir in 2003.

Parameter	EPA Method	Method Detection Limit (mg/kg)	Allowable Hold Time (days)	Max. Hold Time Achieved (days)
<b>Conventionals</b>				
Moisture	160.3	0.50		1
<b>Metals</b>				
Antimony	6010B	3.07	180	2
Arsenic	6010B	2.32	180	1
Beryllium	6010B	0.274	180	1
Cadmium	6010B	0.251	180	1
Chromium	6010B	0.930	180	1
Copper	6010B	0.883	180	1
Lead	6010B	3.67	180	1
Mercury	7471A	0.0128	180	2
Nickel	6010B	0.930	180	1
Selenium	6010B	2.18	180	2
Silver	6010B	0.697	180	1
Thallium	6010B	4.32	180	1
Zinc	6010B	0.837	180	1
<b>Acid/Base Neutral Extractables</b>				
1,2,4-Trichlorobenzene	8270C	160	40	2
1,2-Dichlorobenzene	8270C	160	40	2
1,2-Diphenylhydrazine	8270C	160	40	2
1,3-Dichlorobenzene	8270C	160	40	2
1,4-Dichlorobenzene	8270C	160	40	2
2,4,6-Trichlorophenol	8270C	160	40	2
2,4-Dichlorophenol	8270C	160	40	2
2,4-Dimethylphenol	8270C	160	40	2
2,4-Dinitrophenol	8270C	3,100	40	2
2,4-Dinitrotoluene	8270C	310	40	2
2,6-Dinitrotoluene	8270C	160	40	2
2-Chloronaphthalene	8270C	160	40	2
2-Chlorophenol	8270C	160	40	2
2-Nitrophenol	8270C	160	40	2
3,3'-Dichlorobenzidine	8270C	310	40	2
4,6-Dinitro-2-methylphenol	8270C	780	40	2
4-Bromophenyl-phenylether	8270C	160	40	2
4-Chloro-3-methylphenol	8270C	310	40	2
4-Chlorophenyl-phenylether	8270C	160	40	2
4-Nitrophenol	8270C	780	40	2
Acenaphthene	8270C	160	40	2
Acenaphthylene	8270C	160	40	2
Anthracene	8270C	160	40	2

Table 2-4. (Continued).				
Parameter	EPA Method	Method Detection Limit (mg/kg)	Allowable Hold Time (days)	Max. Hold Time Achieved (days)
<b>Acid/Base Neutral Extractables (Continued)</b>				
Benzidine	8270C	3,100	40	2
Benzo(a)anthracene	8270C	160	40	2
Benzo(a)pyrene	8270C	160	40	2
Benzo(b)fluoranthene	8270C	160	40	2
Benzo(g,h,i)perylene	8270C	160	40	2
Benzo(k)fluoranthene	8270C	160	40	2
bis(2-Chloroethoxy)methane	8270C	160	40	2
bis(2-Chloroethyl)ether	8270C	160	40	2
bis(2-Chloroisopropyl)ether	8270C	160	40	2
bis(2-Ethylhexyl)phthalate	8270C	310	40	2
Butylbenzylphthalate	8270C	310	40	2
Chrysene	8270C	160	40	2
Dibenz(a,h)anthracene	8270C	160	40	2
Diethylphthalate	8270C	310	40	2
Dimethylphthalate	8270C	310	40	2
Di-n-butylphthalate	8270C	310	40	2
Di-n-octylphthalate	8270C	310	40	2
Fluoranthene	8270C	160	40	2
Fluorene	8270C	160	40	2
Hexachlorobenzene	8270C	160	40	2
Hexachlorobutadiene	8270C	310	40	2
Hexachlorocyclopentadiene	8270C	780	40	2
Hexachloroethane	8270C	160	40	2
Indeno(1,2,3-cd)pyrene	8270C	160	40	2
Isophorone	8270C	160	40	2
Naphthalene	8270C	160	40	2
Nitrobenzene	8270C	160	40	2
N-Nitrosodimethylamine	8270C	310	40	2
N-Nitroso-di-n-propylamine	8270C	160	40	2
N-Nitrosodiphenylamine	8270C	160	40	2
Pentachlorophenol	8270C	780	40	2
Phenanthrene	8270C	160	40	2
Phenol	8270C	160	40	2
Pyrene	8270C	160	40	2

### 2.7.1 Regression Analysis

The spatial and temporal distributions of the historical data were examined to determine which parameters had a sufficient time series to warrant meaningful trend analysis. Among the stations monitored for the major water quality parameters (e.g., nutrients, dissolved oxygen, total dissolved solids), downstream station WA-1 and reservoir station WA-2 were consistently sampled over the entire 23-year time series. Water quality trend analyses were limited to the spring (April through June) and summer (July through October) periods. The "spring season" analyses were conceptualized as representing long-term trends associated with inputs to the reservoir during snow melt periods. The "summer season" analyses represented conditions during periods of maximum productivity and most severe low DO stress. Trends at station WA-1 were analyzed separately to evaluate conditions in the Lehigh River downstream of the reservoir. Regression analyses were used to determine if significant change in parameter concentrations occurred over the past two decades. The slope of the regression line was used to estimate the yearly rate of change. For this report, regression analysis was applied to the water quality parameters: total nitrogen, total phosphorus, total dissolved solids, biochemical oxygen demand, and fecal coliform bacteria.

### **2.7.2 Mann-Kendall Analysis**

In addition to regression analysis, the non-parametric Mann-Kendall test was used to determine trends for individual stations over the time span of historical monitoring at F.E. Walter Reservoir. The Mann-Kendall (or Seasonal Kendall) test scores all combinations of yearly change for the tested parameter with a +1 or -1 depending on whether parameter increased or decreased over the time interval. All of the scores are then summed and compared to the chi-square distribution to determine if the parameter has a significant trend (increasing or decreasing) over the time series. For this report, the Mann-Kendall test was applied to the water quality parameters: dissolved oxygen, ammonia, total nitrogen, total phosphorus, total dissolved solids, biochemical oxygen demand, and total and fecal coliform bacteria.

## **2.8 DRINKING WATER MONITORING**

Drinking water was monitored in the operations building of F.E. Walter Reservoir (Table 2-1). Drinking water parameters were divided into Sets A and B. Set A comprised bacteria parameters, total and fecal coliform (for analytical methods, see section 2.4), and nitrate and nitrite. Set A samples were collected 10 June and 24 September. Set B samples were analyzed for primary and secondary contaminants and were monitored 10 June. Table 2-5 summarizes the analytical methods, method detection limits, and sample hold times for each Set B parameter. All of the drinking water quality parameters were analyzed within their respective maximum allowable hold times during 2003.

## 2.9 METEOROLOGICAL MONITORING

Air temperature, relative humidity, solar radiation, wind speed and direction were monitored every ½ hour with a YSI 6200 meteorological station installed and maintained at the F.E. Walter Reservoir discharge tower. Local weather conditions were recorded with these units from May through September 2003 (Appendix E).

## 2.10 LEHIGH WATER QUALITY MONITORING

Ambient water temperature was recorded every ½ hour with Onset Computer Corporation TidbiT<sup>™</sup> probes at five stations along the Lehigh River. The station locations were WA1 (just below the F. E. Walter dam outfall), mainstem station LH3 (several miles downstream of the dam), LH10 (Lehighton), LH15 (Walnutport), and LH17 (Northampton treatment plant intake).

Table 2-5. Analytical methods, method detection limits, and sample hold times for drinking water monitored at F.E. Walter Reservoir in 2003				
Parameter	Detection Limits	EPA Method	Allowable Hold Times (Days)	Maximum Hold Time Achieved (Days)
Aluminum	0.02	200.8	183	2
Antimony	0.003	200.8	183	2
Arsenic	0.005	200.8	183	2
Barium	0.4	200.8	183	2
Cadmium	0.001	200.8	183	2
Chromium	0.02	200.8	183	2
Copper	0.005	200.8	183	2
Iron	0.02	200.7	183	3
Lead	0.001	200.8	183	2
Magnesium	0.5	SM3111B	183	2
Manganese	0.005	200.8	183	2
Mercury	0.0004	245.1	28	1
Nickel	0.005	200.8	183	2
Selenium	0.01	200.8	183	2
Silver	0.005	200.8	183	2
Sodium	0.5	SM3111B	183	2
Thallium	0.001	200.8	183	2
Zinc	0.005	200.8	183	2
Chloride	1	300.0	28	1
Cyanide, free	0.04	335.4	14	7
Fluoride	0.5	300.0	28	1
Foaming Agents	0.025	SM 5540C	2	2
Nitrate as N	1	300.0	2	1

Nitrite as N	0.1	300.0	2	1
Table 2-4. (Continued)				
Parameter	Detection Limits	EPA Method	Allowable Hold Times (Days)	Maximum Hold Time Achieved (Days)
PH	+/-0.01	SM4500H-B	N/A	0
Sulfate	1	300.0	28	1
Total Dissolved Solids	1	SM2540C	7	1
N/A – Not applicable				